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חוק הפטנטים, תשכ"ז - 1967
PATENTS LAW, 5727-1967

בקשה לפטנט
Application for Patent

אני, (שם המבקש, מענו - ולגבי גוף מאוגד - מקום התאגדותו)
I, (Name and address of applicant, and, in case of a body corporate, place of incorporation)

ECI TELECOM LTD.
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(an Israeli Company)

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(חברה ישראלית)

Inventor(s): Oren Marmur

הממציא(ים): אורן מרמור

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METHOD AND SYSTEM FOR COMMUNICATION PROTECTION

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חתימת המבקש Signature of Applicant		היום 3 בחודש November שנת 1999.		

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METHOD AND SYSTEM FOR COMMUNICATION PROTECTION

ECI TELECOM LTD. 	אי. סי. איי טלקום בע"מ

The Inventor:

Oren Marmur 	אורן מרמור

ECIP/F005/IL

Field of the Invention

The present invention relates in general to optical networks, and in particularly to optical telecommunication networks and to methods of using them.

Background of the Invention

Telecommunication systems comprising a number of optical transmission channels are known in the art. Unfortunately, these systems suffer occasionally from a fault occurring in one of these channels, e.g. due to failing components. Therefore, a protection channel is usually incorporated in such systems, allowing the diversion of transmitted communication to a non-failing channel, the protection channel. Traditionally, monitoring the performance in these telecommunication systems was done while incorporating various alarm conditions. Such alarm conditions alerted a human operator when certain events e.g. a loss of signal or error rates that had exceeded pre-defined thresholds were detected. In response to such an alarm, the operator would manually switch to a redundant path in the network, allowing the communication to continue.

At a later stage, conventional fiber optic fibers have implemented 1:1 redundancy for the optical channels in a network, with a certain amount of automatic switching. In these systems, when a loss of signal (to be

referred to hereinafter as "LOS") or alarm indication signal ("AIS") conditions were noted in a channel connecting a first location to a second location, a diversion of the transmission to the available redundant path was made. This diversion enables the transmission of data between these first and second locations to continue.

US 4,646,286 discloses a system wherein a protection switch is effected by detecting a channel failure at receiving end. Thereafter, a protection request is transmitted on the return channel to the transmission end. This request is then used in a controller for the channel to activate a switch to the corresponding protection channel.

However, since this solution requires doubling both the cabling and the input/output ports as compared with those required to carry traffic, such a solution is quite expensive.

Another solution was described in US 5,479,608 that discloses a telecommunication system having 1:N group protection. By this type of solution one redundant channel is allocated to protect a number of operative channels. According to this solution, in response to the detection of an error condition, a request is transmitted to the other side of the system to activate the protection channel.

Summary of the Invention

It is an object of the present invention to provide an optical system that allows continued transmission of messages in case of a failure in a transmission path by using an alternative transmission path.

It is yet another object of the present invention to

provide a system that comprises a combination of protection means and means for automatic system shut down.

It is still another object of the present invention to provide method for diverting transmission from a failing transmission path to an alternative protection path.

Other objects of the invention will become apparent as the description of the invention proceeds.

In accordance with the present invention, there is provided in an optical transport network comprising an optical transmission and reception links extending between first and second locations and carrying traffic in normal operation mode from the first location to the second location and protection transmission and reception links for carrying the traffic of the optical transmission and reception links in the event of a fault in at least one of the optical links, a method for managing routing of traffic to the protection links, which method comprises the steps of:

detecting a fault on an optical link at the second location;

determining whether the total energy received over the reception optical link at the second location exceeds a pre-defined threshold;

in the case that the total energy thus received does not exceed the pre-defined threshold, switching at the second location the traffic transmission and reception to the corresponding protection links;

detecting a fault on an optical link at the first location;

determining whether the total energy received via said optical links at the first location exceeds the pre-defined threshold; and

in the case that the total energy thus received does not exceed the pre-defined threshold, switching at the

first location the traffic transmission and reception to the corresponding protection links.

In accordance with the present invention there is provided in an optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of channels for carrying traffic in normal operation mode from the first location to the second location and at least one protection channel for carrying traffic channel in the event of a fault in at least one of the channels carrying traffic in normal operation mode, a method for managing routing of traffic to the protection channel, comprising the steps of:

detecting a fault on at least one of the channels carrying traffic in normal operation mode, at the second location;

switching at the second location the transmission and reception paths associated with said at least one failing channel to the at least one protection channel;

detecting a fault on said at least one channel at the first location; and

switching at the first location the transmission and reception paths associated with said at least one failing channel to the at least one protection channel.

According to an embodiment of the present invention the at least one protection channel is used for protecting one pre-designated channel of the plurality of telecommunication channels.

According to another embodiment of the invention the at least one protection channel is used for protecting a plurality of telecommunication channels.

In accordance with still another embodiment of the invention there is provided in an optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of channels for

carrying traffic from the first location to the second location, at least one protection channel for carrying the traffic of at least one forward channel in the event of fault in said at least one forward channel, a method for allowing continuous operation of non-failing channels provided that the overall transmitted energy in the non-failing channels exceeds a pre-defined threshold.

According to another aspect of the invention, there is provided an optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of forward channels for carrying traffic in normal operating mode from the first location to the second location, at least one protection channel for carrying the traffic of at least one forward channel in the event of fault in said at least one forward channel, wherein when a failure occurs in one or more of said telecommunication channels, a continued operation of the non-failing telecommunication channels is allowed, provided that the overall transmitted energy in said non-failing telecommunication channels exceeds a pre-defined threshold.

Preferably, the optical transport network of the invention comprises:

a plurality of optical transmitters;

a wave division multiplexer receiving outputs from said plurality of optical transmitters over a plurality of optical channels;

at least one pair of optical links comprising a transmission link and a reception link;

at least one pair of protection links comprising a transmission link and a reception link;

at least one protection channel;

a wave division demultiplexer capable of receiving an input from said division multiplexer over one of said transmission links;

a plurality of optical receivers, each receiving an input from said wave division demultiplexer;

a detection means for detecting a loss of signal in at least one failing channel out of the plurality of optical channels;

a determination means for determining whether the energy of the input received from said division multiplexer exceeds a pre-defined threshold;

a blocking means operative to block all laser beams leaving said wave division multiplexer responsive to a determination of said determination means that the energy thus received does not exceed the pre-defined threshold; and

a protecting means operative to divert traffic from said at least one failing channel to said least one protection channel in the event of fault in said at least one forward channel, provided that the energy of the input received from said division multiplexer exceeds the pre-defined threshold.

Brief Description of the Drawings

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings in which:

Fig. 1A illustrates a typical configuration of an optical protection module, where Figs. 1B and 1C illustrate a configuration of an input optical switch and an output optical switch, respectively;

Fig. 2 is a flow chart describing a sequence of events occurring when a protection action is required;

Figs. 3A to 3D demonstrate operation of a system according to an embodiment of the present invention while switching from normal operating mode to a protection mode; and

Fig. 4 presents a functional block diagram of an optical protection module according to an embodiment of the invention.

Detailed Description of the Invention

Reference is now made to Fig. 1, which illustrates schematically a preferred embodiment of a wave division multiplexing communications system constructed and operative in accordance with a preferred embodiment of the present invention.

The following example describes an Optical Protection Module (to be referred to hereinafter as "OPM") in accordance with the present invention. One of the main purposes of having such an OPM is to perform line protection and IO protection at the optical level, similarly to the SDH MSP 1+1 and IOP protections.

The OPM unit can be separated or an add-on unit to the LOS Detection unit. In the latter case, the need for additional LOS detection mechanisms and electrical control components is eliminated.

Typically, the OPM occupies a single CCP slot, forming together with the LOS Detection unit a double slot unit. The OPM unit includes two sets of fiber connectors, each containing 3 fibers. The first set includes 2 fiber inputs and 1 output, while the second set includes 1 fiber input and 2 outputs. Over all, the OPM unit receives 4 fiber from the line direction and 2 fibers from the LOS detection unit direction. Fig. 1A presents OPM card configuration.

The first set of optical fiber interfaces contains two fiber connectors for two fibers coming from the line direction (one operative and the other for protection), and one output fiber towards the LOS Detection unit card. The two input fibers are connected to a 2x1 optical

switch, which alternately can connect each one of the input fibers to the output fibers.

Fig. 1B depicts the connection between the 2 input and one output fibers.

Similarly, the two output fibers of the second set of fiber interfaces are connected to another 2x1 optical switch, which can alternately connect each one of them to the single output fiber. Fig. 1C depicts the connection between the two output and one input fibers.

LOS detection is not required within the OPM unit itself, since the LOS Detection unit can perform the LOS detection operation. This way, the OPM card includes only the two optical switches, and no additional hardware is required.

The use of two optical switches, instead of an optical switch and an optical splitter is intended to avoid the power loss of 3-4 dB, in case the optical signal is splitted between the operative and protective fibers. As will be further shown, although switches are used at both ends, the protection mechanism can operate without exchanging information between the two ends of the network (such as an APS algorithm).

Fig. 2 demonstrates a flow chart of a sequence of events taking place when a link failure occurs and a protective action is required.

Since the required LOS detection time is less than 1 msec, and the optical switch switching time should be under 4 msec, the whole protection procedure could be completed under 10 msec.

As previously explained, one type of optical protection is OMS/OTS layer protection. According to such type of protection, a set of multiplexed signals is protected between two adjacent optical network elements ("NE"). The protection procedure is somewhat similar so other ring protections known in the art, e.g. in SDH networks, but is carried out at the optical layer.

Another type of protection is the Och layer protection. The Och protection is provided for individual channels (wavelengths). In this case, separate channels are transmitted either on the operative or the protection fibers. Consequently, two different transponders may be required per channel. Contrary to the previous type of protection discussed, this type of protection is preferably carried out at the add and drop direction and not in the optical ring direction.

The following figures 3A to 3D present the system operation scheme in normal operating mode as well as in the protection mode.

Fig. 3A presents the system in normal operation mode. The four fibers, two operative and two protection fibers are connected at both ends to OPM units **400** and **410**, respectively, which in turn are connected to LOS Detection units **420** and **430**, respectively.

Fig. 3B illustrates the stage that a fiber break occurs in the point designated as **440**. The fiber LOS is detected by the LOS Detection unit **420**, which performs automatic shut down procedure. Once the shut down procedure is initiated, OPM **400** switches to protection mode as illustrated in Fig. 3C. Such a switch triggers a LOS in LOS Detection unit **430**, and once this LOS is detected, OPM **410** will switch too to a protection mode (Fig. 3D), completing the system's required switch to the protection mode.

Following the second protection switching, all traffic is transmitted via the protection fibers. The entire operation is typically completed in less than 10 msec, and thus the LOS detection mechanism will not be triggered (an operation that typically requires about 500 msec). The protection fibers are now connected to LOS Detection unit and therefore if a fiber break occurs on

one of the protection fibers, LOS detection will be triggered and will cause a shutdown of all traffic.

The OPM unit according to the present Example comprises of the following main components:

- 6 SC fiber connectors, 3 inputs and 3 outputs.
- 2 2x1 optical switches.
- DC Power supply.

No additional components are required in this Example since all the control circuitry is included in the LOS Detection unit.

Fig. 4 presents a functional block diagram of the OPM unit. The figure presents the main functional blocks and their inter-relations, and should not be interpreted as a detailed and exact hardware layout.

As mentioned previously, LOS detection will be provided by the LOS Detection unit, through the control FPGA, which will be used for controlling the optical switched onboard the OPM card.

In order to control the OPM unit, additional outputs are required from FPGA onboard the LOS detection card. Therefore the FPGA is incorporated once again, including the additional signal.

Two main additional outputs are required - OPM_Switch_En and OPM switch position. The OPM_Switch_En signal controls the two optical switches and should change its value from 0 to 1 or from 1 to 0 upon LOS detection. As mentioned previously, the signal should be kept fixed for 10 msec, although LOS is still being detected, in order to enable completion of the protection action.

The following table 2 lists some relevant technical specification of the OPM unit.

Table 2 - technical Specifications of the OPM unit

Component	**Parameter**	**Value**	**Units**	**Remarks**
Optical Switch Unit	Insertion Loss	<0.5	dB	
	Switching Time	<4	msec	
	Switch_Pos	0 - Switch in Normal Position 1 - Switch in Protect Position		
FPGA	OPM_Switch_En Hold off time.	10	msec	Ignore LOS detection until completion of protection action.

It will be appreciated that the above described methods may be varied in many ways, including but not limited to, changing the exact implementation used. It should also be appreciated that the above described description of methods and networks are to be interpreted as including network in which the methods are carried out and methods of using the network components.

The present invention has been described using non-limiting detailed descriptions of preferred embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. It should be understood that features described with respect to one embodiment may be used with other embodiments and that not all embodiments of the invention

have all the features shown in a particular figure. Variations of embodiments described will occur to persons of the art. Furthermore, the terms "comprise", "include", "have" and their conjugates, shall mean, when used in the claims "including but not necessarily limited to".

Claims:

1. In an optical transport network comprising an optical transmission and reception links extending between first and second locations and carrying traffic in normal operation mode from the first location to the second location and protection transmission and reception links for carrying the traffic of the optical transmission and reception links in the event of a fault in at least one of the optical links, a method for managing routing of traffic to the protection links, which method comprises the steps of:

detecting a fault on an optical link at the second location;

determining whether the total energy received over the reception optical link at the second location exceeds a pre-defined threshold;

in the case that the total energy thus received does not exceed the pre-defined threshold, switching at the second location the traffic transmission and reception to the corresponding protection links;

detecting a fault on an optical link at the first location;

determining whether the total energy received via said optical links at the first location exceeds the pre-defined threshold; and

in the case that the total energy thus received does not exceed the pre-defined threshold, switching at the first location the traffic transmission and reception to the corresponding protection links.

2. In an optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of channels for carrying traffic in normal

operation mode from the first location to the second location and at least one protection channel for carrying traffic channel in the event of a fault in at least one of the channels carrying traffic in normal operation mode, a method for managing routing of traffic to the protection channel, comprising the steps of:

detecting a fault on at least one of the channels carrying traffic in normal operation mode, at the second location;

switching at the second location the transmission and reception paths associated with said at least one failing channel to the at least one protection channel;

detecting a fault on said at least one channel at the first location; and

switching at the first location the transmission and reception paths associated with said at least one failing channel to the at least one protection channel.

3. A method according to Claim 2, wherein said at least one protection channel is used for protecting one pre-designated channel of the plurality of telecommunication channels.

4. A method according to Claim 2, wherein said at least one protection channel is used for protecting a plurality of telecommunication channels.

5. In an optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of channels for carrying traffic from the first location to the second location, at least one protection channel for carrying the traffic of at least one forward channel in the event of fault in said at least one forward channel, a method for allowing continuous

operation of non-failing channels provided that the overall transmitted energy in the non-failing channels exceeds a pre-defined threshold.

6. An optical transport network comprising a plurality of telecommunication channels extending between first and second locations, the channels comprising a plurality of forward channels for carrying traffic in normal operating mode from the first location to the second location, at least one protection channel for carrying the traffic of at least one forward channel in the event of fault in said at least one forward channel, wherein when a failure occurs in one or more of said telecommunication channels, a continued operation of the non-failing telecommunication channels is allowed, provided that the overall transmitted energy in said non-failing telecommunication channels exceeds a pre-defined threshold.

7. An optical transport network, comprising:

a wave division multiplexer receiving outputs from said plurality of optical transmitters over a plurality of optical channels;

at least one pair of optical links comprising a transmission link and a reception link;

at least one pair of protection links comprising a transmission link and a reception link;

at least one protection channel;

a wave division demultiplexer capable of receiving an input from said division multiplexer over one of said transmission links;

a plurality of optical receivers, each receiving an input from said wave division demultiplexer;

a detection means for detecting a loss of signal in at least one failing channel out of the plurality of optical channels;

a determination means for determining whether the energy of the input received from said division multiplexer exceeds a pre-defined threshold;

a blocking means operative to block all laser beams leaving said wave division multiplexer responsive to a determination of said determination means that the energy thus received does not exceed the pre-defined threshold; and

a protecting means operative to divert traffic from said at least one failing channel to said least one protection channel in the event of fault in said at least one forward channel, provided that the energy of the input received from said division multiplexer exceeds the pre-defined threshold.

By the Applicants,

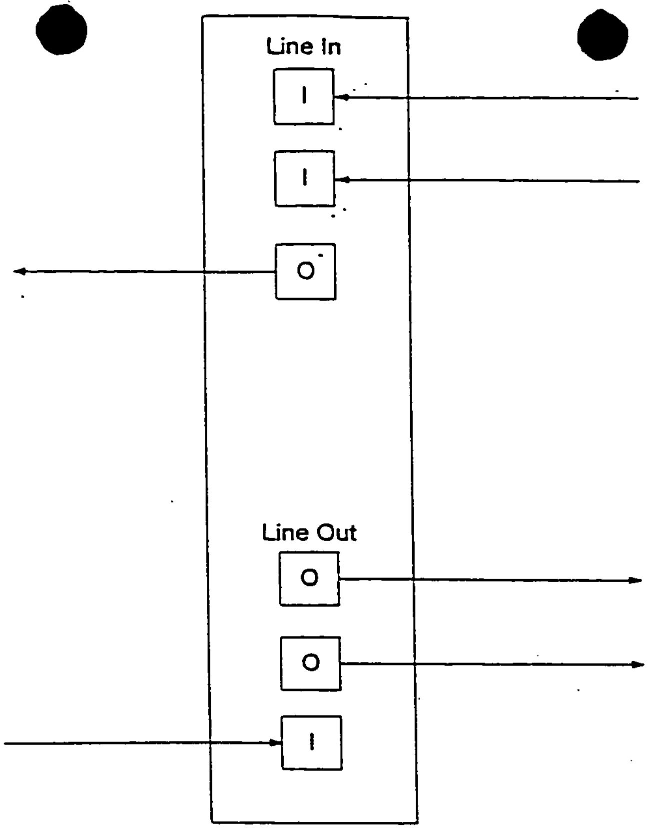

Fig 1A

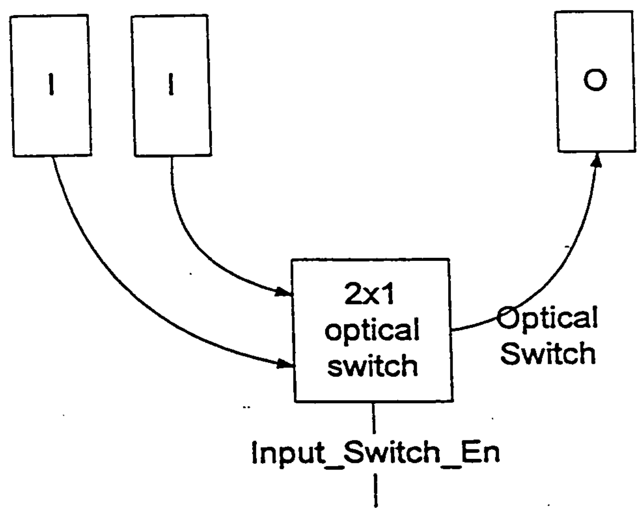

Fig 1B

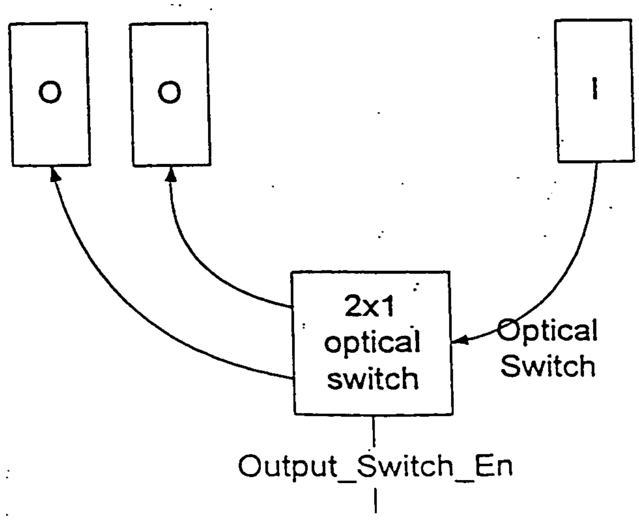

Fig 1.C

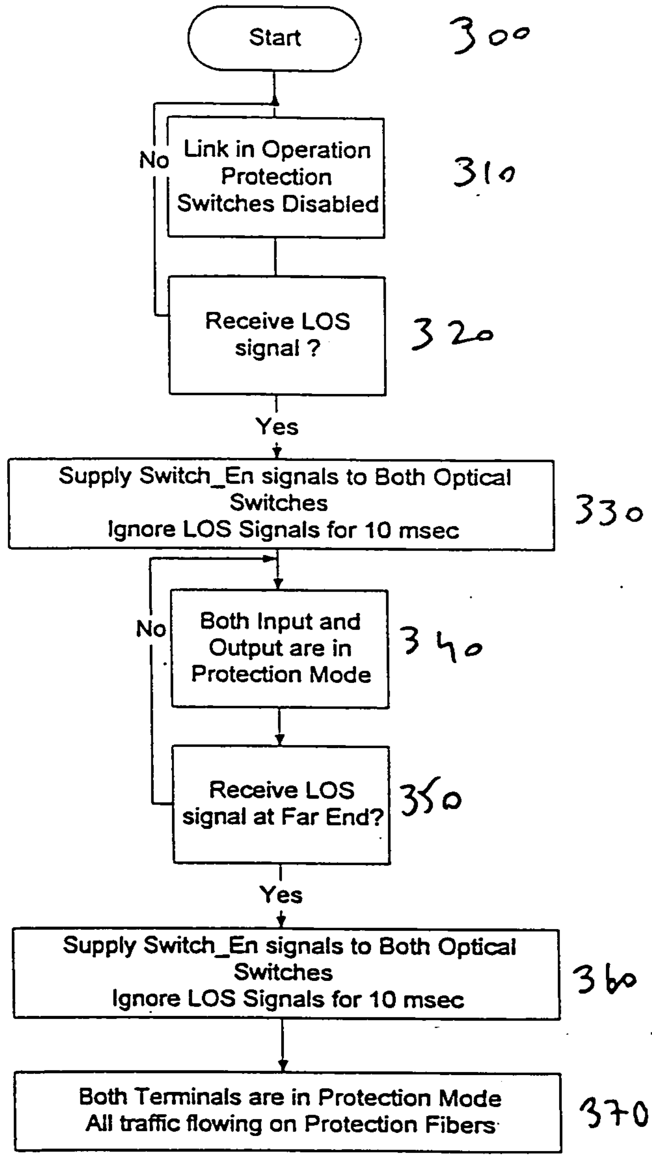
Start
300
No
Link in Operation Protection Switches Disabled
310
Receive LOS signal ?
320
Yes
Supply Switch_En signals to Both Optical Switches
Ignore LOS Signals for 10 msec
330
No
Both Input and Output are in Protection Mode
340
Receive LOS signal at Far End?
350
Yes
Supply Switch_En signals to Both Optical Switches
Ignore LOS Signals for 10 msec
360
Both Terminals are in Protection Mode
All traffic flowing on Protection Fibers
370

Figure 2

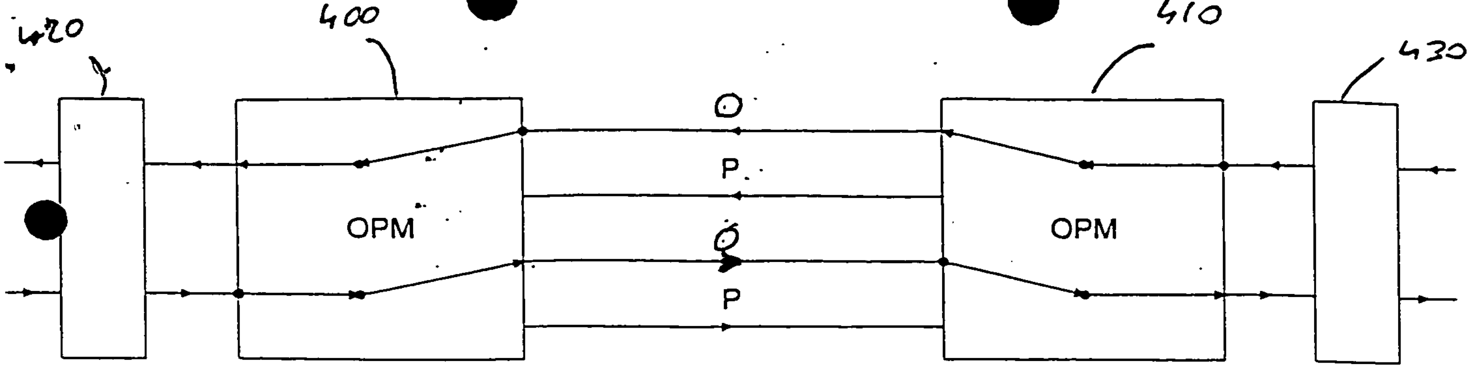

Figure 3A

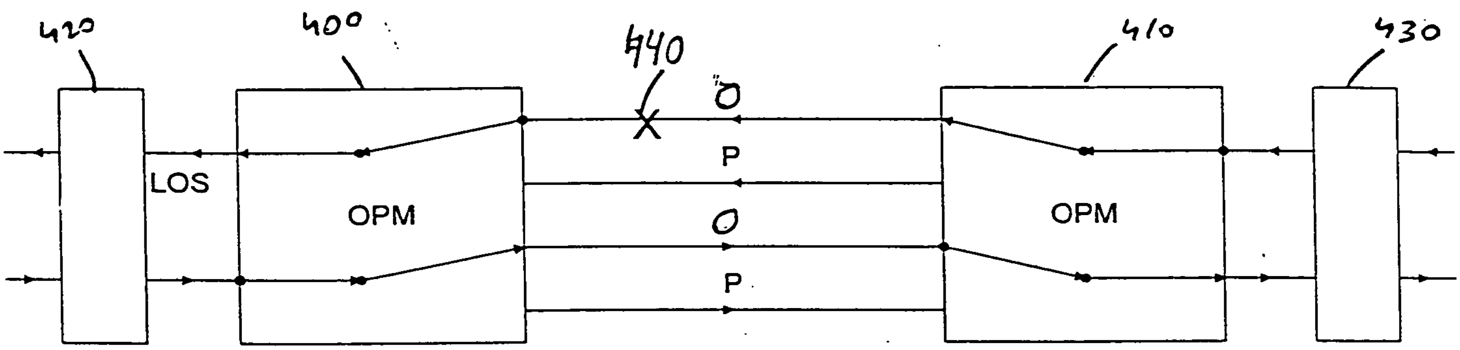

Figure 3B

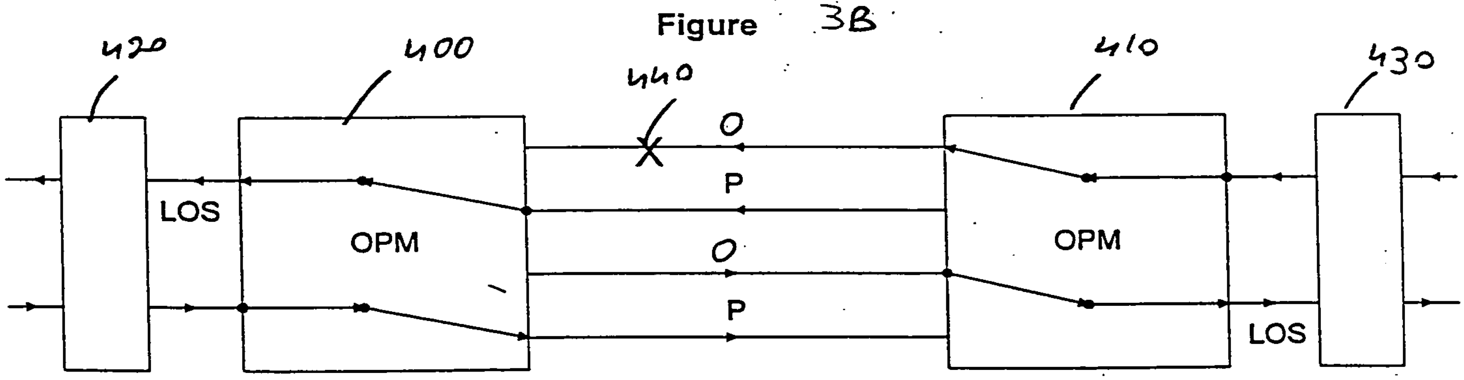

Fig 3C

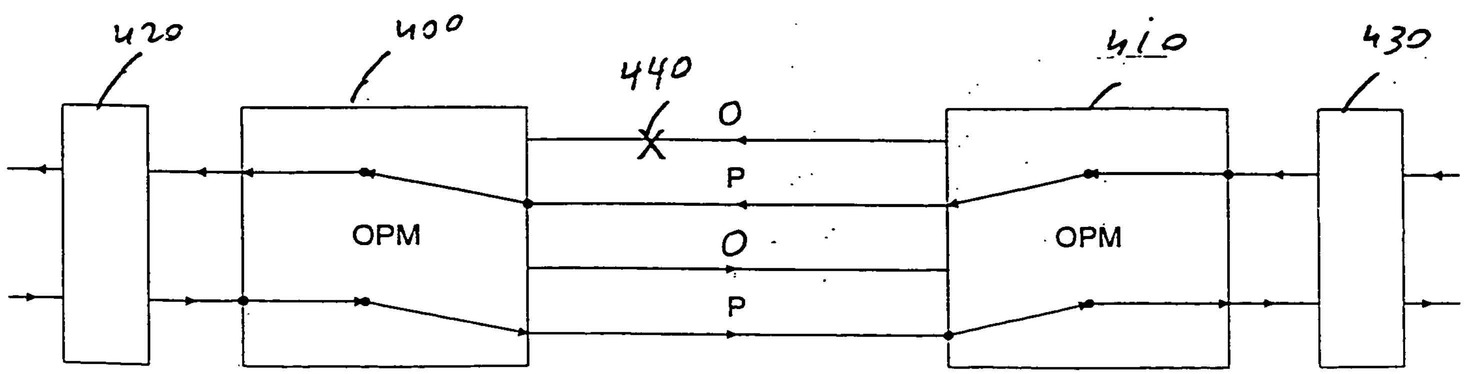

Figure 3D

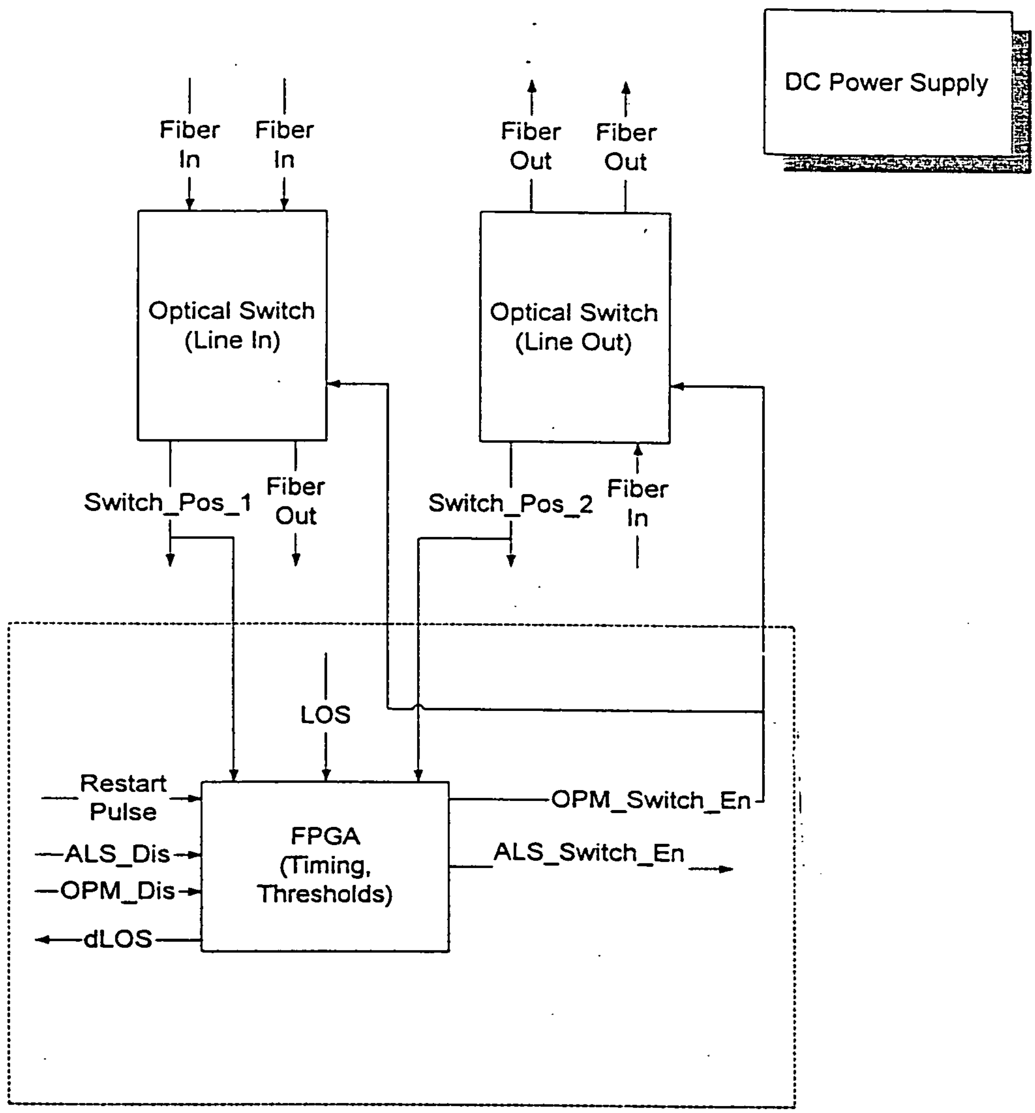
DC Power Supply
Fiber In
Fiber In
Fiber Out
Fiber Out
Optical Switch (Line In)
Optical Switch (Line Out)
Switch_Pos_1
Fiber Out
Switch_Pos_2
Fiber In
LOS
Restart Pulse
ALS_Dis
OPM_Dis
dLOS
FPGA (Timing, Thresholds)
OPM_Switch_En
ALS_Switch_En

Fig 4